SEMIANNUAL PROGRESS REPORT -- NASA GRANT NAGW-1655

"Magnetospheric and Auroral Processes"

Time covered in report: 3/1/90-8/31/90

Scientific Results and Plans for Next Year

P.4

1. Magnetospheric Convection Modeling

Progress was made on the following two projects within the semiannual period:

A. Simulations of the magnetic storm of April 1988 using the Magnetospheric Specification Model;

B. Improvement of a user-oriented electric-field model.

However, neither of these projects had reached fruition by the end of the August 1990. For the sake of efficiency, therefore, we will describe these efforts in the next semi-annual report.

2. Empirical Studies of Polar Cap Convection

In the past year we have continued our studies of the dependence of the convection pattern on the IMF. We were asked to review magnetospheric convection for the Hakone substorm meeting, and work is in progress pulling together all the relevant material for that talk, and the publication to follow from it. We are including in that talk a review of our latest results - that the functional form of the dependence of the potential on the IMF does not strongly depend on solar cycle (therefore on polar cap conductivity). Our student helper also found that that functional form also is independent of the phase of the substorm as well.

Concerning the convection pattern itself, our paper outlining multiple-cell convection drivers [Reiff and Burch, 1985] has sparked a good deal of research in possible observable distinctions between, for example, a "four-cell" convection pattern and a "distorted two-cell" pattern, in which the sunward flow is just a perturbation on an otherwise normal two-cell convection pattern. Working with R. A. Heelis of the University of Texas at Dallas, we have obtained a sequence of orbits in which a strong sunward flow in the central polar cap is observed, both in the Northern and Southern hemisphere. By using the integrated electric potential, one can show the necessary flow pattern using either a four-cell model or a distorted two-cell model. There are several possible configurations for the distortion of the two-cell, but in each case there is at least one area in which the distorted two-cell model would require a flow component along the spacecraft track which is opposite to that observed. Thus, although we do not argue that distorted two-cell patterns do not occur, we present evidence that at least at times a four-cell pattern is most consistent with the flow data. This work is being written up [Reiff and Heelis, 1990; Heelis and Reiff, 1990].

3. Auroral Processes

Our extensive analysis of four magnetic conjunctions of DE-1 at high altitudes and DE-2 at lo altitudes [Reiff et al., 1986; 1988; 1989] has continued apace, with graduate student Gang L examining the mutual self-consistency of the electric currents derived in at least three ways: b integrating the particle distribution; by calculating the curl of the magnetic field; by calculating th

divergence of the horizontal ionospheric Pedersen current [Smiddy et al., 1980)]; and by calculating the predicted current from the high altitude density and temperature plus the total potential drop. In each case the agreement is very encouraging, but some areas of interest remain. At some times the parallel potential drop is of the sense to accelerate electrons downward, but the presence of a cold upward-flowing component of the electrons results in a net current which is actually downward. In general, the Knight formula [Knight, 1973; Lyons, 1980, 1981] appears to be verified, and an empirical coefficient of about 0.5-2 x 10-9 appears to be the best-fit ratio between the parallel current (A/m^2) and the parallel potential drop (V). A paper on this subject has been submitted to the **Journal of Geophysical Research** [Lu et al., 1990]; in addition, the full electrodynamic study of these aurorae is the basis for her Ph.D. thesis, which was completed this half-year.

We have also investigated the effects on spacecraft and on the ground of a major auroral storm which occurred on March 13-14, 1989. Auroras were observed as far south as Brownsville, Texas, and power outages as far south as Los Alamos, New Mexico were experienced. Over six million people depending on the city of Quebec for their electric power were in the dark for 9 hours when a transient current induced in a tranmission line tripped the breakers and then overloaded the system. The DE-1 spacecraft observed the largest auroral oval it ever recorded. A study of these effects was published in EOS [Allen et al., 1989]; and a summary was be published in Sky and Telescope [Reiff and Allen, 1990].

4. Methods of Statistical Analyses

In response to a request from M. A. Shea, we presented a talk at the 1989 IAGA discussing techniques of data analysis and their pitfalls. That paper, an update of our earlier grant-supported work [Reiff, 1983], includes a new discussion of the bootstrap and jacknife techniques, as well as publishes our latest formula for the dependence of the polar cap potential drop on the IMF. The paper [Reiff, 1990] was published this half-year.

New Publications Supported by NAGW-1655

Bergmann, R., H^+-O^+ two stream interaction on auroral field lines, *Physics of Space Plasma* (1989), SPI Conference Proceedings and Reprint Series, Number 9, T. Chang, G. B. Crew, and J. R. Jasperse, eds., in press, Scientific Publishers, Cambridge, MA, 1990).

Fejer, B. G., R. W. Spiro, R. A. Wolf and J. C. Foster, Latitudinal variation of perturbation electric fields during magnetically disturbed periods: 1986 SUNDIAL observations and model results, *Ann. Geophys.*, **8**, 441-454, 1990.

Reiff, P. H. and J. A. Allen, "Devastating Solar Activity in 1989", News Note, *Sky and Telescope*, **79**, (1990), pp. 584-585.

Reiff, P. H., "The use and misuse of statistics in space physics," *Journal of Geomagnetism and Geoelectricity*, **42**, (1990), pp. 1145-1174.

Other Completed Works

Erickson, G. M., R. W. Spiro, and R. A. Wolf, The physics of the Harang discontinuity, *J. Geophys. Res,* (submitted), 1990.

Wolf, R. A., R. W. Spiro, and F. J. Rich, Extension of the Rice Convection Model into the high-latitude ionosphere, *J. Atm. Terrest. Phys.,* (submitted),1990.

Lu, G., P. H. Reiff, J. L. Burch, J. D. Winningham and J. A. Slavin, On the auroral current-voltage relationship, *J. Geophys. Res.,* (submitted), 1990.

Marshall, J. A., J. L Burch, J. R. Kan, P. H. Reiff, and J. A. Slavin, "Sources of field-aligned currents in the auroral plasma", *Geophys. Res. Lett.,* (submitted),1990.

Heelis, R. A. and P. H. Reiff, The ionospheric convection pattern response to changes in IMF direction, *Geophys. Res. Lett.* (in preparation), 1990.

Reiff, P. H., and D. Alexander, Independence of the polar cap potential drop on solar cycle, *Geophys. Res. Lett.* (in preparation), 1990..

Reiff, P. H., and R. A. Heelis, Four cells or two? Are four convection cells really necessary?, *Geophys. Res. Lett.* (in preparation), 1990.

Presentations

Reiff, P. H., "The FY 92 NASA Budget", invited testimony to Space Subcommittee, House Committee on Space, Science, and Technology, March 12 (1990).

Wolf, R. A., "Magnetospheric Structure," two lectures at Rubey Colloquium, UCLA, Los Angeles, CA, March 1990.

Reiff, P. H., "What is a Space Scientist?", "Science Week" talk, Pine Forest Elementary School, April 10 (1990).

Reiff, P. H., "Auroral Electric Fields", Space Physics Departmental Colloquium, Rice University, April 18, (1990).

Wolf, R. A., "Convection Codes, Current State and Prospects," Workshop on the Modeling and the Physics of the Global Magnetosphere, Goddard Space Flight Center; Greenbelt, Maryland; May (1990).

Wolf, R. A., "The Magnetospheric Specification Model," Los Alamos National Laboratory; Los Alamos, New Mexico; June (1990).

Wolf, R. A. and R. W. Spiro, "Coupling of the Magnetosphere and Ionosphere at Auroral and Subauroral Latitudes," COSPAR Meeting; The Hague; July (1990).

Wolf, R. A., "Plasma Sheet Confusion," Gordon Conference on Modeling in Solar Terrestrial Physics; Plymouth, New Hampshire; July (1990).

Theses Awarded, Graduate Students Supported

Bonnie A. Hausman, M. S. Thesis "Particle Fluxes at Geosynchronous Orbit and in the Plasma Sheet During Substorms: Implications for Adiabatic Convection."

Gang Lu, Ph.D. "Auroral Electrodynamics from Simultaneous Measurements at High and Low Altitudes", Department of Space Physics and Astronomy (1990).

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(* Indicates our previous grant-supported work)

*Allen, J. A., H. Sauer, L. A. Frank, and P. H. Reiff, Effects of the March 1989 solar activity, *Eos, Trans. AGU*, November 14, 1989.

*Burch, J. L., P. H. Reiff, R. A. Heelis, J. D. Winningham, W. B. Hanson, C. Gurgiola, J. D. Menietti, R. A. Hoffman and J. N. Barfield, Plasma injection and transport in the mid-altitude polar cusp, *Geophys. Res. Lett.*, **9**, 921-924, 1982.

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Lyons, L. R., The field-aligned current versus electric potential relation and auroral electrodynamics, in *Physics of Auroral Arc Formation*, edited by S.-I. Akasofu and J. R. Kan, p. 252, Geophys. Monogr. **25**, AGU, Washington, D.C., 1981.

*Reiff, P. H., The use and misuse of statistical analyses, in *Solar-Terrestrial Physics*, ed. R. L. Carovillano and J. M. Forbes, D. Reidel, Hingham, MA, 493-522, 1983.

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Smiddy, M., W. J. Burke, M. C. Kelley, N. A. Saflekos, M. S. Gussenhoven, D. A. Hardy and F. J. Rich, Effects of high-latitude conductivity on observed convection electric fields and Birkeland currents, *J. Geophys. Res.*, **85**, 6811-6813, 1980.

*Spiro, R. W., R. A. Wolf, and B. G. Fejer, Penetration of high-latitude-electric-field effects to low latitudes during SUNDIAL 1984, *Ann. Geophys.*, **6**, 39-50, 1988.